INS. KOREANA, 9 : 129~137. September 30, 1992

Insect Systematics in the Changing World: Biodiversity crisis[1)]

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INTRODUCTION

Countless numbers of insects, which are mostly unknown, have relentlessly vanished before our eyes. We will never know they ever existed and what their ecological and evolutionary novelties were. Throughout the world, developmental activities and other anthropocentric technology have eroded or destroyed the integrity and sustainability of many ecosystem processes, which sustain the biological and environmental health of living systems. As a result, much of our natural heritage and evolutionary novelties have rapidly been disappearing (Myers 1979b, Wilson and Peters 1988) and this trend has now reached a crisis point. To meet the needs and demands of more than 5.4 billion people, economic development and urbanization will expand, resulting in a serious environmental degradation. Habitat destruction and environmental pollution will accelerate the process of extinction at a rate unprecedented in the history of our planet. The loss of biodiversity is the ultimate symbolism of the maladies caused by our technological anthropocentricity.

Insects and arachnids constitute the largest group of extant organisms, and they may account for over 90 percent of the world's known fauna (Arnett 1985, Kosztarab and Schaefer 1990). Arthropods are important components of the ecosystems involved in the production and processing of basic organic materials in their habitats. Insects and arachnids are movers of the ecosystem processes (Wilson 1987). For example, mites and springtails are primary inhabitants of terrestrial ecosystems in which they are major processors and recyclers of nutrients in the soil. Our understanding of how the ecosystem functions requires knowledge of insects and related arthropods, and yet, the taxonomy and ecology of these organisms are poorly known (Schaefer and Kosztarab 1991) and research is severly limited.

We are now at the crossroads where our inability to reverse the present trends and revive the basic capacity of the earth's ecosystems may threaten our own survival. At this critical period of human history, systematics, particularly arthropod taxonomy, has important roles to play in regain-

[1]The earlier version was presented in the symposium, "Current State of Research on Insects and Their Environmental Nature in North Eastern Asia," September 30, 1991, Center for Insect Systematics, Chuncheon, Korea. Contribution from the Frost Entomological Museum, Department of Entomology, and Center for Biodiversity Research, Environmental Resources Research Institute, The Pennsylvania State University.

ing the sustainability of ecosystem processes and conserving the global biodiversity.

In this paper I will present my views on biodiversity and the state of insect systematics, and discuss the roles of insect systematics in biodiversity crisis.

BIODIVERSITY AND EXTINCTION

Biodeversity is the basic biotic resources for maintaining the human ecosystem and meeting anthropocentric needs, whereas the synergistic interactions of plants, animals and microbes are the basic mechanism for functioning of the ecosystem process. No single species can survive alone, and an ecosystem cannot function without the primary component species (Odum 1989), many of which are insects and related arthropods. Each species interacts with other organisms, and reacts and adjusts in specific ways to its environment by meeting its niche requirements. The contemporary pattern of biodiversity has been shaped by this process.

Biodiversity refers to variations and varieties of organisms, plants, animals and microbes, naturally including humans. Genetic variations within and between species and their varieties in the context of habitats are the essence of biodiversity. Thus, biodiversity involves all levels of biological hierarchy; gene, population, species, community, ecosystem, and landscape levels (Soulé and Wilcox 1980. Norse et al. 1986, Wilson and Peter 1988).

Extinction is a natural process and has taken place throughout the geological history of organisms (Ehrlich and Ehrlich 1981, Patrusky 1986, Signor 1990). Mass extinctions of the Permian trilobites and the late Cretaceous dinosaurs demonstrate this evolutionary process. Extinction is caused by both biological and physical factors operating at habitat and ecosystem levels (Raup 1991). However, the contemporary extinction rate is alarming because its cause is primarily anthropogenic and its level unprecedented. Many anthropocentric activities, such as development and urbanization, invariably result in the alteration, fragmentation and destruction of habitats (Wilson 1985a,b, Lewin 1986, Wright 1987), and the anthropogenic extinction is getting worse every day. For example, the rate of species loss from deforestation is about 10,000 times greater than natural extinction prior to the appearance of human species (Wilson and Peters 1988, Silver and DeFries 1990).

Biodiversity is quite sensitive to environmental changes (Odum 1989, Saunders et al. 1990), although some changes may be subtle and undetected. Every species with an unique genetic endowment occupies a specific niche in the habitat with a particular set of encological requirements. It plays specific roles in the ecosystem process and has specific sensitivity to particular environmental pollutants. Thus, its reactions to environmental changes are swift and often detrimental and its disappearance may not be detected for a long time, if ever.

For the past 50 years, human endeavors have polluted the environment and destroyed the natural habitats of many plants and animals. This resulted in the extinction of many species, such as the Chapman's rhododendron, the green sea turtle, and the passenger pigeon. At the present rate, more than 15 percent of world biodiversity will disappear from the planet earth by the year 2000, perhaps numbering 500,000 to 600,000 species (Myers 1979a, Lovejoy 1980). For the United States flora

alone (20,000 species), more than 3,000 plant species may become extinct. With rapidly increasing human population and ever expanding urbanization, the processes of necessary economic development will further aggravate the destruction of natural habitats and, thus, results in species extinction, unless specific strategies for their protection are implemented.

With biodiversity loss, we are permanently destroying the most basic biotic resources, with which the ecosystem functions. We already face the dramatic effects of environmental maladies of the technological society. Our concern over the global climatic change is the symbolism of what we may encounter in the near future. Human extinction is no longer a fiction but a possibility, as we are increasingly threatened by anthropogenic maladies. Furthermore, tens of thousands of plant and animal species of potential economic values are disappearing without even being known what and how useful they are. To alleviate the possibility of human extinction, we will need new innovations and technologies for solving anthropogenic problems (Krauthammer 1991).

ASPECTS OF BIODIVERSITY

Since Linnaeus (1753, 1758), approximately 1.5 million species of plants, animals and microbes (Wilson 1985a,b), perhaps as many as 1.82 million (Collins cited by Stork 1988), have been described and named. They include 440,000 species of plants, 47,000 vertebrates and some 751,000 species of insects (Arnett 1985). It appears that this fingure represents barely 10 percent or less of the extant biodiversity. Although the true size of the global diversity is debatable (May 1986, 1988, 1990, Stork 1988, Erwin 1991), the true numbers are much higher than what has been described and may be somewhere between 10-30million species (Erwin 1982, 1983, Wilso 1985a, Gaston 1991). There is an urgent need for assessment of local biodiversity throughout the world, particularly in the areas where habitats and ecosystems are being threatened. Biodiversity inventory and assessment provide the basis for science and important human endeavors, such as environmental assessment, development strategy, and land-use planning (Kim and Kuntson 1986a).

Humans are a natural species; this implies that humans have an innate requirement of "being with nature" or biophilia (Wilson 1984). We the human species, must closely link ourselves to "nature" as we need clean air and water to survive. To sustain the human civilization, biophilia must be brought into human consience. This will not only heighten the environmental and evolutionary value of biodiversity in our psyche but also bring back to the human society an innate altruism, peace and tranquility.

Biodiversity is directly linked to most aspects of human life and anthropocentric endeavors. Yet, most of us do not realize the fact that the materials we use and food stuff we consume have originated from wild species of organisms; only a small part of the biodiversity with potential economic value has been utilized. Compelling practical aspects of biodiversity include the use and application of economic species of plants, animals and microbes in major human endeavors, such as agriculture, biotechnology, industry, pharmaceuticals and medicines (Myers 1979a, Kim and Knutson 1986b).

Almost 90 percent of the food supply in the world is provided by only 20 species of plants; 3 spe-

cies and their varieties, namely wheat, rice, maize, fill more than 50 percent of the world food basket (Myers 1979a,b, 1983a,b). There are many hundreds, perhaps thousands of plant species that are edible and even better than the crop species currently being cultivated. Furthermore, the gene pool of cultivated varieties need genetic input from related wild species. As biotechnology makes use of the knowledge of species and germplasms accumulated over the last 200 years, aggressive research on biodiversity, particularly those species that are unknown or poorly studied, will provide expanded material basis and will enhance its advances (Markle and Robin 1985).

As the use chemical pesticides is significantly reduced, biological control has increasingly gained its importance as a viable means to reduce pest populations. Classical biological control by natural enemies, which begins with taxonomy and distribution of the pest species and potential natural enemies, has successfully controlled many important pest species (DeBach 1974, Knutson 1981). In other words, successful biological control programs require good taxonomic informantion (Klassen 1986). Yet, our knowledge on the biodiversity of insects and arachnids is quite limited and information on taxonomy and distribution for the known species is scarce.

BIODIVERSITY OF INSECTS AND ARACHNIDS

The species richness of insects and arachnids has been the subject of debate for some time. The number of known species has been estimated differently as 751,000 species for insects (Arnett 1985), 874,161 species for arthropods (Wolfe 1987), and 827,000 species for insects (Gaston 1991). The figure of one million described species for insects and arachnids seems to be reasonable and commonly accepted by systematists. The most contentious issue has been the question of how many species there are in the extant fauna (Sabrosky 1952, May 1986, 1987, 1990, Stork 1988. Adis 1990, Erwin 1991, Gaston 1991), particularly since Erwin (1982, 1983) reported that there may be as many as 30 million species of arthropods with Coleoptera being a most dominant taxon. Although there is no definite way to measure the species richness, a commonly-held estimate is less than 10 million species for arthropods (Gaston 1991).

In 1989, North American insect systematists got together to discuss the taxonomy of North American insects and arachnids and made an estimate of the North American fauna. The North American fauna is estimated ass 200,000 species of which only 50 percent of the extant fauna has been described. In other words, to complete the more than 1 million new descriptions and illustrations for all life stages of 100,000 unknown insects and arachnids it will take at least 525 scientists and 525 illustrators for a period of ten years (Kosztarab and Schaefer 1990).

INSECT SYSTEMATICS IN BIODIVERSITY CRISIS

The state of knowledge on taxonomy of insects and arachnids is not very good, as the analysis of North American fauna clearly demonstrated. Furthermore, while the demand for identification of in-

sects and arachnids has increased, the available expertise and specialist's work hours for identification and taxonomic research have decreased drastically for the last two decades. Insect systematics is facing a double wham when research and inventory in biodiversity urgently need to be exlpanded.

Insect systematics has lagged behind the other disciplines of biology. As the global fauna of insects is estimated as 10 million species, our taxonomic knowledge is limited to less than 10 percent of extant species (Arnett 1985). Even for the North American fauna which is considerably better known than others, our taxonomic knowledge barely covers about 50 percent of the extant biodiversity of insects and arachnids (Kosztarab and Schaefer 1990). Thus, most insect systematists have devoted their research efforts on revisions and descriptions of new species and alpha taxonomy as a major thrust will likely be continued for the next 20-30 years until at least 50 percent of the global biodiversity of insects and arachnids is described and named. In comparison, the biodiversity of vascular plants and vertebrates has been well documented representing perhaps as much as 80 percent of extant vascular plant diversity and more than 90 percent of the vertebrates, taxonomy and biogeography of these plants and animals are well known and much of the necessary information for conservation is already available. However, for insects and related arthropods our knowledge on phylogeny, infraspecific variations and ecology is scarce.

The demand for taxonomic information and services has rapidly increased, while the number of taxonomists and financial resources for taxonomic research have declined for the last 50 years (Kim 1975a,b, Lattin and Knutson 1982, Haskell and Morgan 1988, Kosztarab and Schaefer 1990). In North America there are a few hundred taxonomists who are competent to identify insects and arachnids. However, most specialists work only part-time in taxonomy, as their primary duties are assigned to other activities such as teaching at universities and applied research at federal and state laboratories. There is an acute shortage of replacements in insect systematics. In the survey by J.D. Lattin (1984), of 82 professors of systematics of insects and arachnids at U.S. universities, only 25 (30%) were training 1 or 2 graduate students in systematics during 1984 (Kosztarab and Schaefer 1990), and many were about to retire. The trend has not changed since 1984 and in fact is getting worse. Similarly, financial and organizational support for systematics has been declining and is getting worse (Oliver 1988); only approximately $38.6 million were spent on systematics in the United States for the year 1985 (Wilson 1985a,b).

In the context of conservation strategy, the black box of arthropods has been conveniently set aside because of their high species richness and scarcity of taxonomic knowledge. For the last 30 years conservation strategy has been species-oriented, concentrating on aesthetically magnificent megaspecies and "keystone"species. Biodiversity conservation is still focused on species or a group of species based on the same criteria, and as a result, most arthropods are excluded in conservation strategies. As the strategy moves from species to ecosystems, arthropods and related invertebrates become increasingly important and must be inventoried and monitored for ecosystem conservation.

BIODIVERSITY CONSERVATION AND SYSTEMATICS IN KOREA

The peoples of Korea are faced with tremendous political and economic challenges. In the ever-competitive world with the expanding human population, economic development must be continually expanded, whereas prospect of the united Korea brings to both of the divided country new dimensions in the future of Korean people, particularly in the areas of land-use planning and conservation. For the future generations of Koreans, the remaining biodiversity and landscapes must be protected and preserved.

Systematists must play a pivotal role in meeting these goals. The first step toward these challenges is the inventory and assessment of Korean biota through which the profile and pattern of the Korean biodiversity will be described. Toward the united Korea, systematists and conservationists should band together to develop the Korea Peace Bioreserves System in the areas of the Demilitarized Zone (DMZ). This project will bring systematists from both Koreas and other interested countries for research.

The DMZ is 14km (=8.7 miles) wide belt crossing from the east to the west coast, 245km (= about 200 miles); 2km wide territory on both sides of the line (4km=2.5miles) with 5km boundary zone on each side of the central belt. By accessing the area next to contiguous with the DMZ the areas for biodiversity reserves can be expanded to 16km (=10 miles) wide. This zone includes rugged mountains in the east and low hills and plains in the west. Since it was established, this zone has been uninhabited and rigidly protected. This forced inaccessibility has made positive values for environmental research and biodiversity conservation unanticipated in the original settlement. The DMZ provides a tremendous opportunity for science and the future generations of Koreans. The time is here to begin the assessment of biodiversity and habitats and research on the dynamics of ecosystem processes in this natural laboratory.

FUTURE PERSPECTIVES ON SYSTEMATICS

Systematics is the science of biodiversity and the most fundamental and inclusive discipline within the biological sciences. Alpha taxonomy provides descriptions and related baseline data on species with which taxonomic services are provided for all user communities in biological and environmental sciences. Biological classification developed by systematists is the basic scientific theory and information bank upon which all other biological research is based and evolutionary inferences are made on phylogeny of organisms. Understanding extinction processes requires the knowledge of speciation.

Biodiversity cannot be conserved in isolation. Conservation and restoration of biodiversity requires an interdisciplinary approach to research and development of strategies (Humphrey and Stith 1990). This includes the inventory and assessment of biodiversity and habitats, monitoring of the ecosystem processes, and their preservation and restoration.

The biodiversity inventory is the first step in the conservation effort and this provides the most basic data on species such as distribution, habitats, biotic changes (spatial and temporal) and taxo-

nomic status. Inventory and survey activities generate collections of specimens which are samples of species populations. The need of biological inventory and assessment has been stated over and over by both systematists and conservationists (Kosztarab 1984, Kim and Knutson 1986a,b, Green and Losos 19888, Kim 1988, Oliver 1988), and some progress has been made at national and international levels.

Insect systematics as a science will continue to meet the tasks of alpha-and betataxonomy and .study the phylogeny and evolutionary process of insects and arachnids. The application of taxonomic information will continuously expand in many aspects of human life. Taxonomic data on species will become an integral part of conservation strategy. Insect systematists need to be aggressive and vigilant because we must understand the global biodiversity of insects and arachnids as much as we can before many of the undiscovered species permanently disappear. Without adequate information on the fauna, taxonomic analyses and evolutionary inferences will be limited and, thus, the phylogenetic inference and classification of insects and arachinds will be incomplete.

ACKNOWLEDGEMENTS

I thank Ms. Judy Cranage of the Penn State Center for BioDiversity Research for her kind assistance in preparing this manuscript. My appreciation also goes to James L. Frazier, C. W. Pitts, Ho-Yeon Han, Joseph Slusark and Il-Byung Yoon for reading this manuscript with useful comments.

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(Received : Sept. 30, 1991)